# Chapter 4
# Simulation Software

Banks, Carson, Nelson & Nicol

*Discrete-Event System Simulation*

## Classification of Simulation Software

- General-purpose programming languages
  - Flexible and familiar
  - Well suited for learning DES principles and techniques
  - E.g.: C, C++, Java
- Simulation Programming Language
  - GPSS,SIMAN,…
- simulation languages (Simulation environments)
  - Good for building models quickly
  - Provide built-in features (e.g., queue structures)
  - Graphics and animation provided
  - E.g.: Arena, Automod,…

## Selection simulation Software

- Model building feature
- Runtime environment
- Animation of layout features
- Output features
- Vendor support and product documentation



## Model building feature

- Modeling world-view
- Input data analysis capability
- Graphical model building
- Conditional routing
- Simulation programming
- Syntax
- Input flexibility
- Modeling conciseness
- Randomness
- Specialized components and templates
- User-built objects
- Interface with general programming language

## Runtime environment

- Execution Speed
- Model size; number of variables and attributes
- Interactive debugger
- Model status and statistics



## Animation of layout features

- Type of animation
- Import drawing and objects file
- Dimension
- Movement
- Quality of motion
- Libraries of common objects
- Navigation
- Views
- Display step
- Selectable objects
- Hardware requirments

## Output features

- Optimization
- Standardized Report
- Statistical Analysis
- Business Graphic
- File Export
  - Database



## Vendor support and product documentation

- Training
- Documentation
- Help system
- Tutorials
- Support
- Upgrades, maintenance
- Track report

## The Checkout Counter: A single server example

- The simulation will be run until 1000 customers have been served
- Inter-arrival of customers are exponentially distributed with mean 4.5 and service times are normally distributed with a mean of 3.2 minutes and standard deviation 0.6 minutes



## The Checkout Counter: Variables

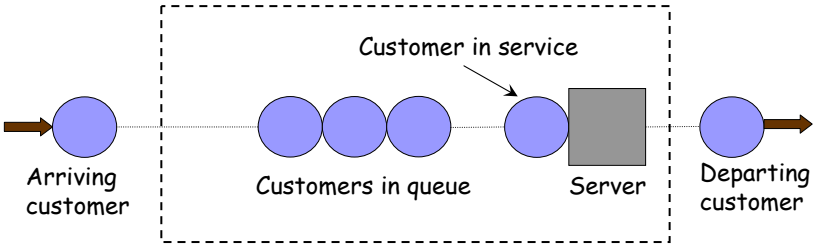
| | |
|---|---|
| System state | ***QueueLength ,NumberInService*** |
| Entity attributes and set | ***Customers*** FCFS queue of customers |
| Future event List | ***FutureEventList*** |
| Activity duration\ions | ***MeanInterArrivalTime,MeanServiceTime*** |
| Input parameters | ***MeanInterArrivalTime,MeanServiceTime***<br>***SIGMA*** standard deviation ***TotalCustomers*** (The stopping criterion) |
| Simulation variables | ***Clock*** |
| Statistical accumulators | ***LastEventTime ,TotalBusy***<br>***Max QueueLength ,SumResponseTime***<br>***NumberOfDepartures ,LongService*** who spends 4 or more minutes |
| Summary statistics | ***RHO=BusyTime/Clock*** Proportion of time server is busy<br>***AVGR*** average response time ,***PC4*** proportion of customers who spent 4 or more minutes |

## The Checkout Counter: Functions and Methods

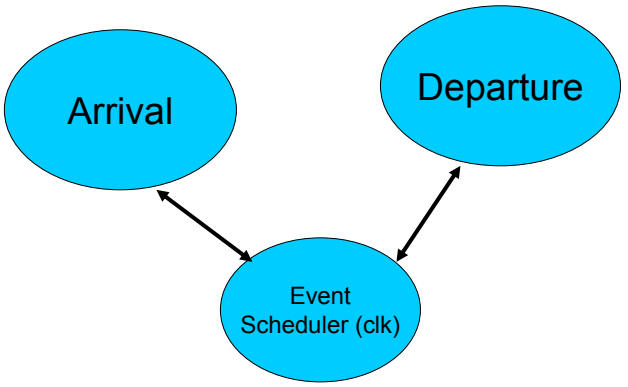
- Functions
  - exponential (mu)
  - normal (xmu,SIGMA)
- Methods
  - Initialization
  - ProcessArrival
  - ProcessDeparture
  - ReportGeneration



## Global View

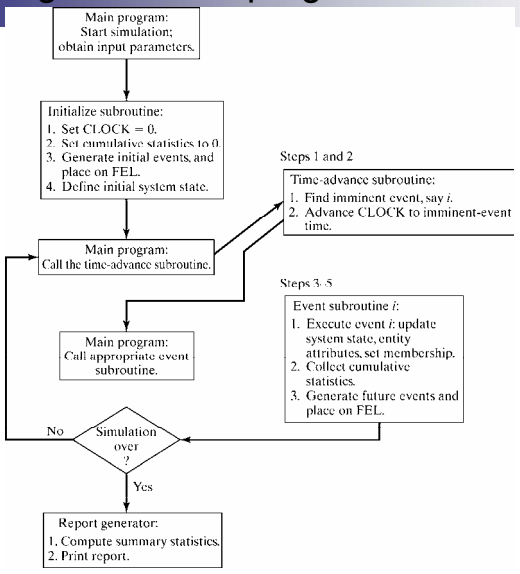


# Modules( Functions, Objects,…)

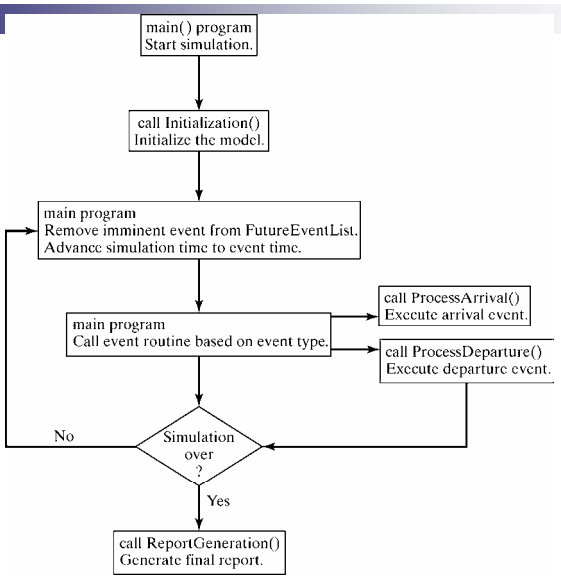





# Simulation with java : Over structure of an event scheduling simulation program



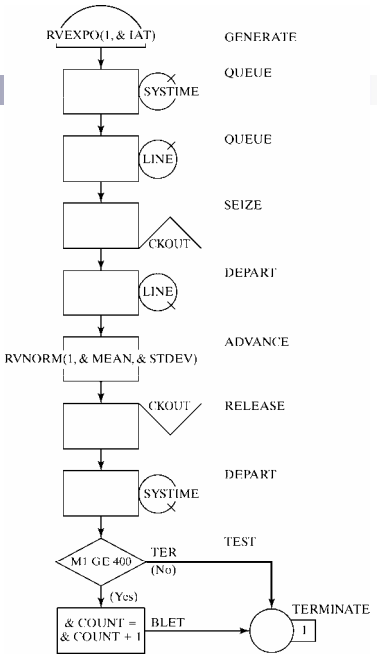
# Java simulation of a single server






# Simulation in GPSS Single server

GPSS is highly structured, special purpose simulation language based on the process interaction and oriented toward queuing system



## Other simulation tools

- Arena
- Automod
  - Autostat
- Extend
- Flexim
- Micro Saint
- Promodel
- SIMUL8
- SMPL